Early and favorable action in connection with this application is respectfully requested.

Respectfully submitted,

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senses a focused image of the monitored area whilst the volumetric sensors view of the scene is unfocussed. The field of view of all three detectors is similar and will typically be approximately 90 degrees. The apparatus also includes a processor 5 which receives the outputs of the detectors 2,3,4 and activates an alarm upon determining from those outputs that a flame is present in the monitored area.

[0020] The outputs from the two volumetric detectors 3,4 are electronically processed by known means so as to produce numerical estimates of the overall signal level and of the spectral ratio of the two channels. Temporal analysis of this data will also produce a simple characterisation of the modulation frequencies present in terms of the center frequency and bandwidth, The processor 5 uses this information to give one of three initial assessments of the scene once activity has been detected: flame-like, non flame-like and intermediate. The output of the array detector 2, which in the illustrated embodiment includes a 4.3 um filter 7 to enhance flame discrimination, is also initially analysed to give one of three assessments of the scene: (1) saturation or nonsense; (2) single source present; (3) two or more angularly separated sources present. Finally the processor analyses the temporal and spatial characteristics of each source that is detected to decide whether the data is compatible with known characteristics of a flame and the size of the source in angular terms.

[0021] Using the information obtained from the sensors, the processor is able, then, to analyse the radiation sources identified in the monitored region, and, following the steps shown in the flow diagram in Figure 2, and in tables 1 and 2 below to decide whether and what type of alarm should be activated as explained below in connection with five main scenarios which can be expected to arise in a monitored region.

A' cont.

Table 1
Initial Single Element Analysis

<table>
<tr><th></th><th></th><th>Flame Like</th><th>Intermediate</th><th>Non-Flame Like</th></tr>
<tr><td rowspan="3">Initial Array Analysis</td><td>Saturates or Nonsense</td><td colspan="3">A</td></tr>
<tr><td>Single Source</td><td rowspan="2">B</td><td>C</td><td>D</td></tr>
<tr><td>Two Sources</td><td>E</td><td>F</td></tr>
</table>

Table 2
Decision Tree

Initial Assignment	Likely Scenarios	Decision Tree and output
A	Large close fire or Tamper or Fault	**Warning!** If temperature is showing a large rise: **Alert!** If self rest systems correct and situation persists: **Fire!**
B	Probable fire	**Alert!** If array data confirms flame like features in at least one identified sources then: **Fire!**
C	Deep sooty fire or Composite false alarm	**Warning!** If array data confirms flame like features Then: **Alert!** If source is growing and temperature sensor indicating rise then: **Fire!**
D	Probable False Alarm	**Activity!** Monitor Source using array. If persists And flame-like and grows then: **Warning!**
E	Probable fire in presence of false alarm	Warning! Flame like structure identified in at least one source: **Alert!** If this source grows and temperature sensor registers: **Fire!**
F	Probable fire in presence of false alarm	**Activity!** Monitor larger source using array. If this grows and temperature sensor rises then: **Warning!** Monitor smaller source using array. If any flame like features present or growth observed then: **Warning!**

[0022] In table 1 there are shown six categorized outcomes from the initial assessment that has been carried out by the sensors. Each of these outcomes now becomes the start of a decision tree in which additional data from the sensors is made use of by the processor 5. It will be understood that the analysis suggested by the scheme of Figure 2 and Tables I and 2 is being carried out continuously. Also in a complete instrument further data analysis will be performed that is not relevant to this invention and this could lead to further hardening of the 'possible' and 'probable' categories.

A1 cont.

1) Single False Alarm Source

[0024] Analysis of the output of the array detector 2 reveals that only a single source is present in the target area, (which will typically be a hot object such as a halogen lamp or an electric fire). In a simple case, the output of the array 2 may be sufficient to determine that the object has no flame like characteristics. However, modulation of the source often occurs in practice, for example due to objects moving in front of it, and this can cause flame like characteristics which might result in the output from the array detector wrongly identifying the source as a flame. In the presence of such a false alarm source with no flame present, however, the spectral ratio measured from the source will fall below the predetermined value for a flame, and the system of the present invention therefore uses this information as a primary factor in making its determination as to whether or not to activate the alarm. As a secondary check, the array output can be further analysed for flame-like spatial features in the target such as size, movement and shape, and with all detector information combined, the false alarm can be positively identified with a high degree of certainty.

2) Single Flame at close range

[0025] When a flame is present close to the detection apparatus, several pixels of the array sensor will be illuminated, enabling reliable analysis of the source for flame-like spatial characteristics to be carried out, The spectral ratio calculated from the outputs of the unfocussed detectors 3, 4 will also indicate that the source is a flame, and the alarm can be activated with a high level of certainty.

3) Single Flame at long range

[0026] When a flame is present in the viewing area at a long distance from the detection apparatus so that perhaps only a single pixel of the array detector is illuminated, the spectral ratio calculated from the outputs of the unfocussed sensors will still give a good identification of the presence of a flame. The output of the array detector will give greater confidence to this identification since the angular size, position and intensity of the source are known and must follow reasonable limits (e.g. a wide source of low intensity cannot be a flame, and a source that is moving as an entity over large angular distances cannot be a flame). Accordingly, the source can be identified as a flame and an alarm activated with a high probability.

A.1. cont.

4) Both aflame and a false alarm source at close range

[0027] With both a flame and a false alarm source present close to the detection apparatus, the spectral ratio calculated from the unfocussed detectors 3,4 will be corrupted by the radiation emitted by the false alarm source. However, with the flame close to the detector, the value of the spectral ratio will still exceed the predetermined threshold value, leading the processor to determine a flame is present with reasonable certainty. Furthermore, provided both sources illuminate several pixels in separate parts of the array, then structural features such as shape, movement and intensity derived from the array by the processor will provide confirmation of the spectral data arid could also be used, in an advanced configuration, to determine the direction of the fire.

5) A flame at long range and an intense false alarm source

[0028] If a flame is present together with an intense false alarm source, the flame being located at a large distance from the detector, the radiation received by the unfocussed detectors 3,4 will be dominated by the false alarm source so that the spectral ratio calculated from the output of the volumetric detectors 3,4 will fall below the threshold value for the alarm to be activated. However, as long as there is an angular separation between the flame and the false alarm source, the existence of a signal from the flame will indicate that an additional radiation source is present in the

the sun and welding equipment, which further enhances the systems reliability and accuracy.

A1 concl'd

[0032] In an alternative embodiment of the invention not illustrated, the processor could derive an estimate of the total radiation around the 4.3 um wavelength for use in calculating the spectral ratio by summing the total 4.3um radiation incident on the array detector 2. In this way the 4.3um volumetric sensor may be dispensed with. The system may then be further enhanced by provision of a second array sensor which operates at a different wavelength to the first.

[0033] In some situations, it may not be necessary to restrict the wavelengths incident on the array detector to around the 4.3um wavelength. For example, a wide band sensor covering a range of approximately 2um to 15um would image hot objects that were not necessarily flames. This would enable early detection of a smoldering fire or of objects that were heated by an obscured flame. It would also enable the flame detector apparatus to function also as a person or animal sensor in a security application.

[0034] In very severe conditions, it is possible that the apparatus of the invention could be blinded by very intense light or confused by an intense very close fire. In order to overcome this problem, the apparatus could be equipped with additional low cost sensors such as silicon photodiodes for visible light and thermistors or the like to monitor actual temperature and rate of rise of temperature. The provision of such additional sensors would enable the processor to give a reliable indication of the situation in circumstances where the primary detectors are blinded.

[0035] Although the above embodiments have been described in relation to monitoring a region for hydrocarbon flames and the operating wavelengths of the various detectors specified accordingly, it will be understood that the system of the invention may also be utilised to monitor for non-hydrocarbon fires by varying the wavelengths to which the detectors are responsive. For example, if the 4.3um volumetric detector is replaced by one responsive to 2.9 um, the system can be used to monitor for the emissions from hot water vapor.

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